EXPERIMENTAL STEAM CONDITIONER FOR INSHELL PECANS

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ILLUSTRATIONS

EXPERIMENTAL STEAM CONDITIONER FOR INSHELL PECANS

By B. L. Tyson and W. R. Forbus, Jr.[1]

ABSTRACT

A steam conditioner for installation between the washer-destoner and the crackers was designed, built, and tested in a pilot plant. The equipment has the capability of varying quantity of steam, depth of pecans, and total steam-exposure time. The conditioner has been installed in a pecan-shelling plant to evaluate its commercial feasibility. **KEYWORDS: nut-processing equipment, pecans, pecan conditioning, pecan sanitizing, shelling efficiency, steam conditioning.**

INTRODUCTION

Over 90 percent of the U.S. pecan harvest is marketed as shelled halves or pieces. In the United States Standards for Grades of Shelled Pecans, a half is defined as "one of the separated halves of the kernel."[2] A piece is defined as "a portion of a kernel which is less than seven-eighths of a half kernel, but which will not pass through a round opening two-sixteenths inch in diameter." Fragments of kernels that will pass through a round opening two-sixteenths inch in diameter are classified as particles and dust.

A major source of economic loss in the pecan industry is the low and variable yield of halves obtained in shelling operations. In 1965, O. W. Thompson, then director of the Pecan Division of the Cotton Producers Association, stated in a personal communication that the yield of halves ranged from 50 to 80 percent of the nutmeat obtained in shelling plants. Operators therefore have to process large quantities of broken pieces. Pieces are significantly more costly to process than halves, and depending on market conditions, often sell for $0.50 per pound less. Variable yields of halves and pieces also prevent maximum utilization of equipment capacity and maintenance of effective operating schedules.

To improve yields of halves, shellers increase the moisture content of the nutmeat kernels before cracking the shells, to make the kernels more pliable. The conditioning method most widely used involves soaking the inshell nuts for 1 to 2 hours or wetting them for 3 to 5 minutes in water containing 1,000 parts per million of chlorine. (The chlorine sanitizes the shells.) The wet nuts are held in barrels or large bins for 18 to 24 hours before they are cracked so that the nutmeats can absorb moisture. Another method, used to a limited extent, involves soaking the inshell nuts in 185° F water for 3 to 5 minutes and holding them for 8 to 10 hours before cracking. These conditioning methods are somewhat effective in increasing the yield of halves, but considerable variation in yields still exists within and among shelling plants. The primary disadvantage of these methods is that they are batch operations separate from other processing steps, and equipment and handling costs are excessive.

In work aimed at developing improved con-

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[2] U.S. Department of Agriculture Federal Register Document 69–7052 (1969).

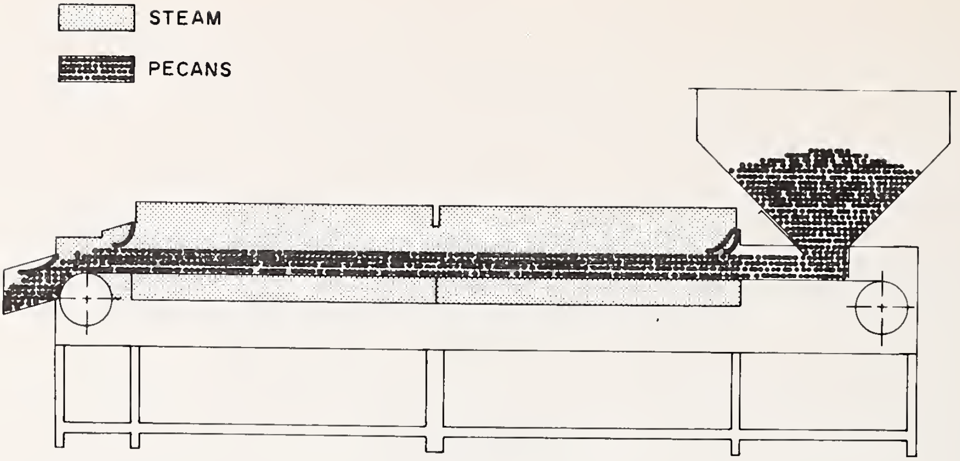

FIGURE 1.—The concept of the inline steam conditioner. From the washer-destoner, pecans are deposited in the hopper at right, from which they are moved by conveyor through a steam tunnel to the crackers. Asbestos flaps at the entrance and exit, represented by thick curved lines, retard the escape of steam from the tunnel.

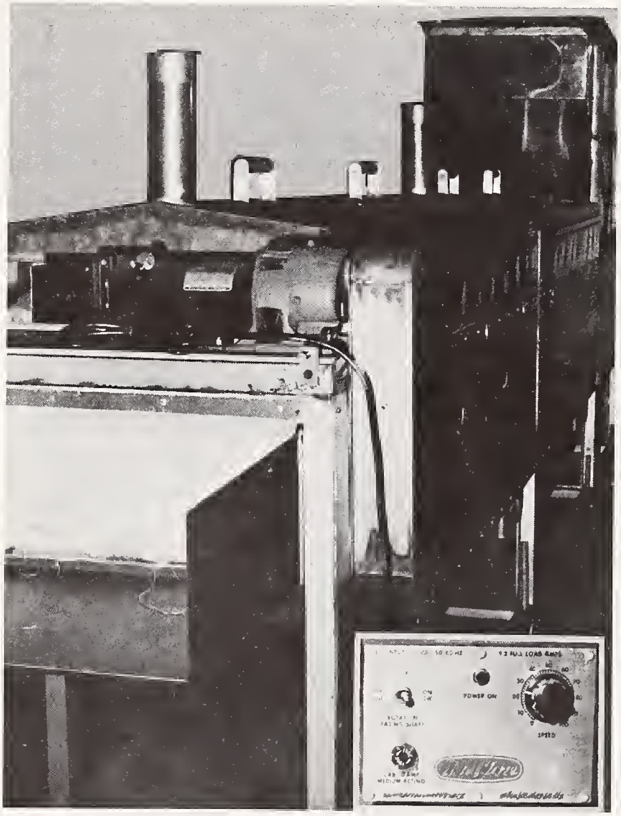

FIGURE 2.—Steam conditioner as converted from vegetable blancher. The receiving hopper is at the far end. The variable-speed drive system (foreground) consists of a controller (black box at left), motor, speed reducer, and chain drive (enclosed in housing at right). The face of the controller is shown in the inset (lower right corner).

ditioning methods, Forbus and Smith[3] found that the percentage of halves obtained in shelling increased with the temperature of the soak water used for conditioning. They recommended that the commercial feasibility of an inline conditioning process employing steam as the wetting medium be investigated. They suggested that, in addition to improving yields of halves, inline steam conditioning could significantly reduce the costs of marketing pecans by reducing processing time, and labor and equipment requirements. They also suggested that steam might be more effective than chlorine in sanitizing the shells.

In pilot-scale experiments, Forbus and Senter[4] showed that a 3-minute steam-conditioning process was superior to existing commercial processes by improving shelling efficiency, pecan quality, and pecan stability during storage. They recommended that additional work be conducted to determine if the results obtained in pilot-scale tests could be achieved in commercial shelling plants. The objective of this work was to develop a full-scale inline steam conditioner that could be installed in a commercial pecan shelling plant for testing.

[3] W. R. Forbus, Jr., and R. E. Smith. 1971. Pecan conditioning methods for increased shelling efficiency. Trans. ASAE 14(3): 596–599.

[4] W. R. Forbus, Jr., and S. D. Senter. 1976. Conditioning pecans with steam to improve shelling efficiency and storage stability. J. Food Sci. 41: 794–798.

STEAM CONDITIONER

The type of equipment needed to efficiently and economically incorporate steam conditioning into existing shelling plants, it was decided, would be a semienclosed conveyor connecting the washer-destoner and the crackers. While moving continuously in bulk on the conveyor, the pecans could be exposed to an atmosphere of steam (fig. 1). Such a conditioner would have to:

1. Provide a continuous flow of product to at least 50 automatic pecan crackers, each having a capacity of 100 nuts per minute (to adequately test the concept).
2. Maintain the above rate for different size pecans, from 60 to 100 nuts per pound, and at variable steam-exposure times between 2 and 6 minutes (to allow adjustment for variable shell moisture, varietal differences, and plant variables).
3. Maintain temperature in the tunnel at 212° F when fully loaded with pecans.

Based on the above design criteria, it was determined that a commercial vegetable blancher could be converted into an inline steam conditioner for pecans. The blancher consisted of a loading section and two steam sections. The vegetables were placed on the equipment at the loading section and transported into the steam sections by a wire-mesh belt. The stainless-steel sidewalls, bottoms, and removable tops of the steam sections formed a tunnel in which the vegetables were exposed to steam as they moved through on the continuous, stainless-steel belt. Steam was supplied to each steam section through a 1¼-inch, black-iron-pipe (wrought-iron-pipe) manifold. The manifolds were mounted along the length of each section at the bottom of the left sidewall inside the tunnel. Six ½-inch, black-iron pipes 22 inches long, each having 8 holes one thirty-second inch in diameter along their length, protruded perpendicularly and horizontally from each manifold every 12 inches along its length. Steam flowed from the manifold through the holes in the horizontal pipes and through the vegetables on the belt from underneath. Each steam section had P-traps for disposing of condensation inside the tunnel and drip caps on top to collect condensate from the lids, which helped form a seal to prevent steam from escaping. The primary modifications necessary were installing a receiving hopper on the loading section, incorporating a device for varying pecan depth on the conveyor, modifying the steam-supply system to permit steam from both above and below the pecans, installing a variable-speed drive to control steam time, and raising the sidewalls of the steam sections to allow for a maximum pecan depth of 8 inches on the conveyor. Eight inches is required when the largest pecans (60 nuts per pound) are being conditioned for the longest steam time (6 minutes).

The maximum required depth was computed as follows:

1. 50 crackers $\times$ 100 nuts/min/cracker $=$ 5,000 nuts/min.
2. 5,000 nuts/min $\div$ 60 nuts/lb $=$ 83.3 lb/min.
3. 83.3 lb/min $\div$ 30 lb/ft^3 $=$ 2.78 ft^3/min.

With a tunnel length of 12 feet and maximum time in the tunnel of 6 minutes, the belt speed is 2 feet per minute. Therefore, 2.78 ft^3/min $\div$ 2 ft/min $=$ 1.39 ft^2, the cross-sectional area of tunnel required. The belt width was fixed at 26 inches, or 2.167 feet. Therefore, 1.39 ft^2 $\div$ 2.167 ft $=$ 0.641 ft, or 7.69 inches, the maximum depth required for the largest pecans.

The conditioner as modified is shown in figures 2–4. The essential components are described in the following sections.

Receiving Hopper and Gate

Inshell pecans will be fed to the conditioner from a commercial washer-destoner; therefore, a receiving hopper (fig. 5) was designed and installed on the loading section to permit adjustment of pecan flow and act as a buffer between loading rate and conditioner capacity. The hopper is constructed of stainless steel, with angle-iron supports and braces. It is 26 inches wide and 60 inches long and mounted so that the top is 44 inches above the belt. The ends are sloped 45 degrees to allow the pecans to slide down toward the opening in the bottom of the hopper. The 12-inch opening in the center of the hopper extends across the width of the belt. The total capacity of the hopper is approximately 700 pounds of inshell pecans.

A gate for regulating pecan depth on the belt was designed and incorporated into the receiving hopper. The device (fig. 6) is a sheet of stainless steel the width of the belt and is

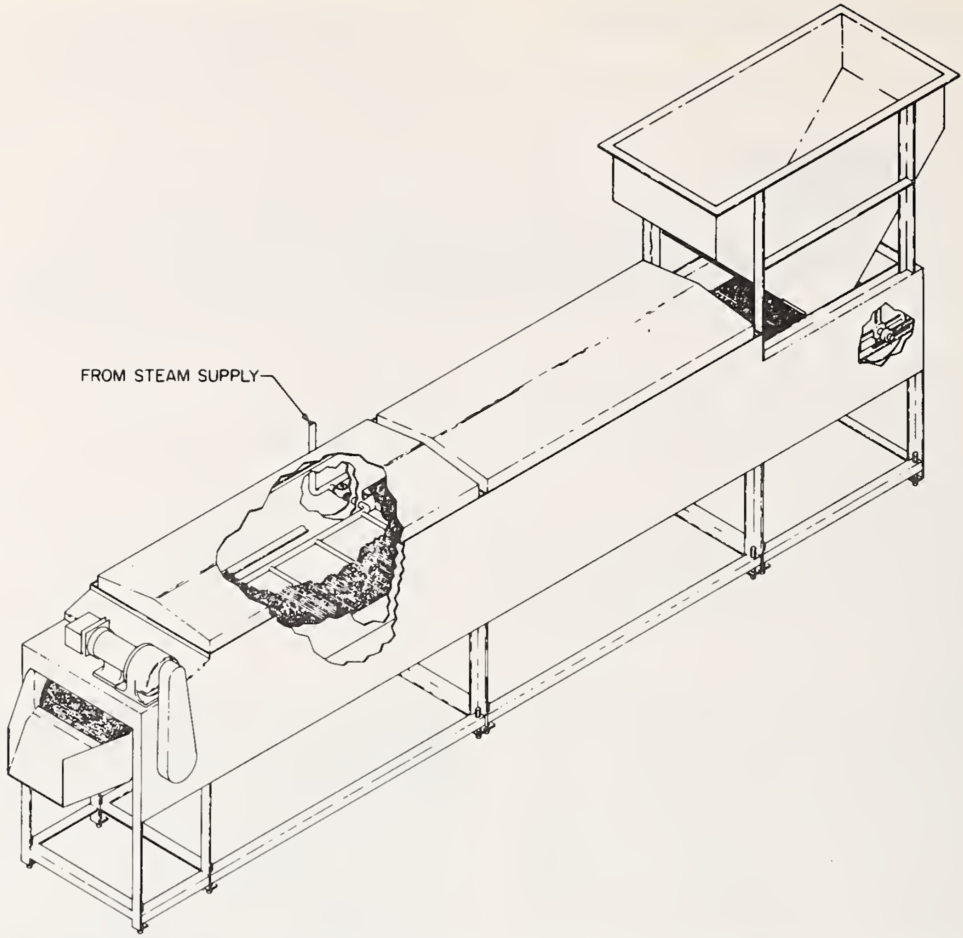

FIGURE 3.—Perspective drawing of steam conditioner. The cutaway in the sidewall under the hopper shows the conveyor-belt adjustment. The near cutaway shows the arrangement of steampipes under the conveyor belt.

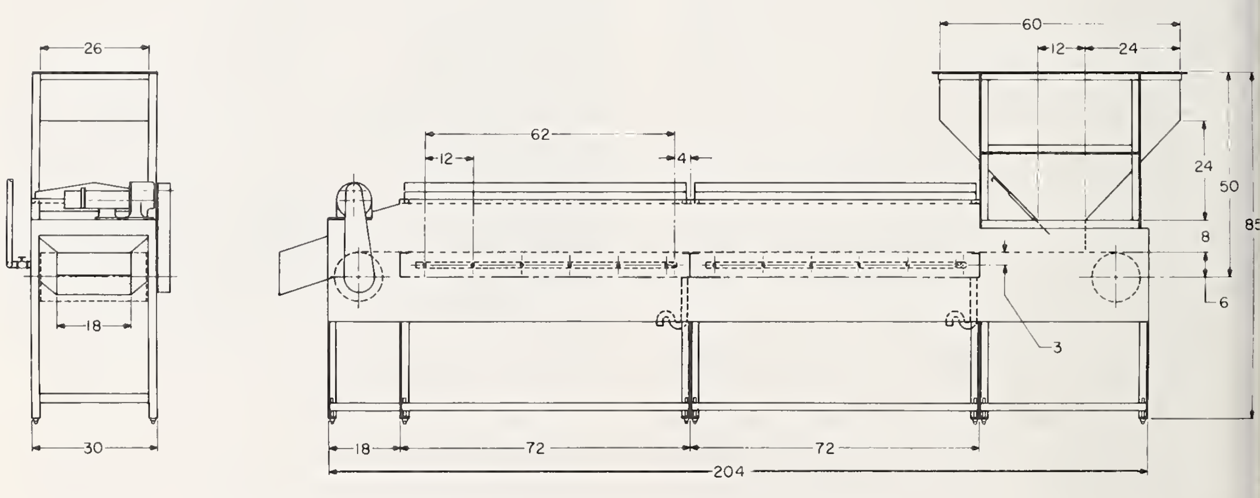

FIGURE 4.—Dimension drawing of steam conditioner. Dimensions are in inches.

mounted to slide up and down a track parallel to the underside of the sloped end of the receiving hopper nearest the steam section. By sliding the gate up and down the track, the vertical distance from the bottom of the gate to the belt can be varied from 2 to 8 inches. Thumbscrews on each side of the hopper are provided for locking the gate in position. The gate, in combination with the variable-speed belt drive, regulates the flow of pecans as required for varying the processing rate of the conditioner.

Steam Section

Pecans are subjected to steam as they are transported through the steam tunnel. Gasket material was installed between the two steam sections of the blancher before they were bolted together, and asbestos curtains were hung over the tunnel entrance and exit to retard the escape of steam from the tunnel (see fig. 1). Also, the stacks on the removable tops were capped for the same purpose. P-traps in the bottom of each section and drip pans on the tops of the sidewalls collect and dispose of condensation.

To introduce steam from above as well as from underneath the pecans, manifolds with steam-distribution pipes identical to the ones below the belt were installed directly above and parallel to the ones underneath the belt. In order to accomplish this and provide space for an 8-inch pecan depth, the sidewalls of the conditioner had to be raised 6 inches. A manifold was also constructed and mounted on the outside of the left sidewall (fig. 7) to deliver steam from the steam supply to the upper and lower manifolds inside the tunnel. Valves were installed at each of the steam-entry ports so that steam flow can be regulated independently at four locations, both above and below the product in the two sections. In addition, the drilled distribution pipes protruding from the manifolds inside the tunnel can be turned to vary the direction of steam flow.

An electric boiler having a belt horsepower rating of 14.4 was used to supply steam to the conditioner. This boiler had an electrical capacity of 144 kilowatts and a pressure range of 0 to 100 pounds per square inch. The rated output was 475 pounds of steam per hour at 212° F. Steam is piped directly from the boiler through the control valves to the manifolds inside the steam sections through 1¼-inch pipe. All exposed steam lines should be well insulated and labeled.

FIGURE 5.—Receiving hopper.

FIGURE 6.—Gate for regulating pecan depth on conveyor belt.

FIGURE 7.—Manifold and valves for regulating steam flow.

Drive Section

A variable-speed drive system was designed and built to allow any belt speed between 6 feet per minute and 2 feet per minute. These limits correspond to 2 minutes and 6 minutes, respectively, that the pecans are in contact with the live steam. Six minutes of steam time would require a belt speed of 12 feet every 6 minutes, or 2 feet per minute. The drive pulley is 1 foot in diameter and hence has a circumference of 3.14 feet ($C=\pi D=3.14\times 1$). Therefore, the pulley moves the belt 3.14 feet per revolution, and the rotation of the pulley is 0.637 revolution per minute (2 ft/min÷3.14 ft/revolution).

To accomplish this belt speed, a $\frac{3}{4}$-horsepower, adjustable-speed drive was used (fig. 2). The drive consists of a totally enclosed, fan-cooled, d.c., permanent-magnet motor powered from and regulated by a 115-volt, 60-Herz controller that supplies d.c.-rectified power to the motor. It has a speed range of 20 to 1 with constant torque. This motor in turn drives an inline speed reducer with a 57.5-to-1 reduction, which brings the minimum full-torque speed down to approximately 2.2 revolutions per minute. To further reduce the drive speed, the speed reducer is connected to the belt drive pulley by a 1-to-4 ratio chain drive, thus bringing the minimum speed to 0.55 revolution per minute.

The belt is a balanced spiral design made from stainless steel, with openings sufficiently small to prevent pecans from falling through. The belt can be alined and tightened on the feed end of the conditioner (fig. 3).

PILOT-PLANT TESTS AND RESULTS

The experimental steam conditioner was tested under pilot-plant conditions. Previous studies had shown that maximum benefit was derived from the steam treatment when the steam chamber was held at a constant 212° F. With this requirement, a systematic search began for the minimum amount and placement of live steam necessary to maintain that temperature. Copper-constantan thermocouples were connected to a multipoint recorder to record the temperature inside the conditioner. Steam was applied as follows: (1) from above in both sections, (2) from below in both sections, (3) from above and below in the first section, (4) from above and below in the second section, (5) from above in the first section and below in the second section, (6) from below in the first section and above in the second section, and (7) from above and below in both sections. Pressure settings on the boiler of 20, 40, 60, and 80 pounds per square inch were also used.

Introduction of steam from below in both sections with a boiler pressure of 80 pounds per square inch gave excellent temperature stability of 212° F. At this pressure the steam output from the boiler was approximately 2,400

pounds per hour, as measured by water input to the boiler.

Pecan flow through the conditioner was excellent, and the gate to regulate pecan depth on the belt worked well. The drive system worked well as designed, but calibration was a little difficult because of the controller's sensitivity.

A problem with high noise level developed as the pecans left the belt and fell onto the stainless-steel chute at the output end of the conditioner. However, the addition of a sound and vibration dampening pad to the underside of the chute reduced the noise to an acceptable level.

The pecan steam conditioner developed and tested in this study was found to be feasible in pilot-plant tests. The conditioner has been installed in a pecan shelling plant, and its commercial feasibility is being evaluated. No major plant modifications were necessary to accommodate the installation.

The equipment as designed is capable of handling a maximum of 40,000 pounds of pecans each 8-hour day. This amount is sufficient to feed 50 pecan crackers.

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